AMS -342

Shipping Florida Citrus Fruit in Wirebound Crates and Cartons

A Comparison of Commercial Practices

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Marketing Research Division
Washington, D.C.

CONTENTS

October 1959

SUMMARY

Preliminary results from six tests indicate that rail shipments of oranges and grapefruit packed in 4/5-bushel wirebound crates and loaded in the "layer-offset" pattern cool at about the same rate as those in telescope cartons with vents on all surfaces, loaded according to the "spaced bonded-block" load pattern.

On arrival at New York City there was very little decay and severe rind breakdown in grapefruit in either container. After a 1-week holding period at 70° F., 4 percent decay developed in crates and 7 percent in cartons, most of which was green mold rot.

There was little, if any, rind breakdown or decay of the test lots of oranges in either container on arrival. During the following week at 70° F., rind breakdown remained negligible. Decay, mostly stem-end rot, increased to 19 percent in both containers.

Under the conditions of these tests, conducted in spring and summer, mechanically refrigerated cars seemed as satisfactory as ice-refrigerated, fan-equipped cars for the transport of citrus loaded while warm and cooled during transit.

When packages of similar dimensions are considered from the standpoint of refrigeration in transit, a more rapid rate of cooling of fruit would be expected to result from loading these packages in a pattern that provides the greatest amount of open space for air circulation through the load.

SHIPPING FLORIDA CITRUS FRUIT IN WIREBOUND CRATES AND CARTONS--
A COMPARISON OF COMMERCIAL PRACTICES

By J. R. Winston, senior horticulturist, Randall H. Cubbedge, biological science technician, and Jack Kaufman, plant pathologist
Biological Sciences Branch, Agricultural Marketing Service

INTRODUCTION

Wirebound crates have long been in general use as citrus shipping containers in Florida with little change in design or loading pattern. By contrast, both container design and load pattern for fiberboard cartons have been modified several times during the past 10 years in attempts to obtain more rapid cooling of the load. An evaluation of the efficiency of various containers and load patterns has been difficult because of the lack of data based on comparable shipping tests. The tests described herein were designed to compare the rates of cooling and the effect on keeping quality of citrus when packed in crates and cartons and loaded in the carrier-approved method for each container.

This study of shipping Florida citrus fruit in wirebound crates and cartons is part of a broad program of research designed to achieve more efficient distribution of our farm products. The purpose of one phase of this research is to evaluate, improve, and maintain the quality of food in transit and while it is moving through marketing channels.

MATERIALS AND METHODS

Wirebound crates of 4/5-bushel capacity, loaded in the customary "crosswise offset" pattern, were compared with telescope cartons with slots or vent openings on all surfaces, loaded in the "spaced bonded-block" pattern (figs. 1 and 2). 1/ The "crosswise offset" pattern is hereinafter called the "layer-offset" pattern, the term by which it is known in Florida.

Both containers and their respective loading patterns met requirements of carriers and were in general use in the Indian River district of Florida, where the test shipments originated.

Loads in ice-refrigerated cars consisted of 1,056 wirebound crates and 1,032 telescope cartons of oranges and 1,094 crates and 1,004 cartons of

1/ Railroad Freight Tariff 823-C, Rule 215 (layer offset method) and Rule 210 (spaced bonded-block method).

BN-7931

Figure 1.--Wirebound crates of 4/5-bushel capacity loaded in the customary "layer-offset" pattern.

grapefruit. Loads in mechanically cooled cars contained 1,404 crates or cartons of oranges.

Six test shipments were made in the spring and early summer of 1958 in paired cars of similar design. For each car loaded with oranges or grapefruit in crates, there was a companion car with the same variety packed in cartons. Test packages of comparable fruit were placed in the middle layer at the quarterlength position of each car for inspection at destination. Each shipment was precooled at least 5 hours starting immediately after loading, and both cars of each pair received the same refrigeration service in transit. Ten electric resistance thermometers were placed in containers in the top, middle, and bottom layers at the bunker, quarterlength, and doorway positions to determine changes in fruit temperatures during precooling. Recording thermometers placed in the bottom bunker, middle quarterlength, and top doorway positions recorded the temperatures in the load from the packing house to New York City.

Ice-refrigerated cars with built-in fans were used in five tests. In test A the cars were precooled with a truck-mounted, portable mechanical precooling unit rated at 40 tons by the operator (Table 1). The bunkers were

(a)

BN-7932

(b)

BN-7933

Figure 2.--Telescope cartons being loaded in the "spaced bonded-block" pattern: (a) Starting of load. (b) Closeup view showing more detail in the advanced loading. This method of loading produces vertical zig-zag channels.

Table 1.--Reduction of temperatures of grapefruit and oranges packed in crates and in cartons after 5 hours of precooling in cars, average of 10 positions, 1958

Test and fruit in test	Type of car and source of refrigeration	Crate		Carton	
		Start of precooling	Reduction	Start of precooling	Reduction
		° F.	° F.	° F.	° F.
A--Grapefruit.....	End-bunker, fan car; portable unit 1/	64.8	9.2	63.5	8.9
B--Do.............	End-bunker, fan car; ice	72.6	2/6.9	75.5	3/8.4
C--Oranges........	Do	78.9	10.2	83.2	10.7
D--Do.............	Do	70.8	2.8	80.4	7.6
E--Do.............	Do	81.7	6.4	79.1	8.1
Average........		73.8	7.1	76.3	8.7
F--Oranges........	Built-in mechanical refrigeration unit	79.3	4.8	80.2	3.7

1/ Forty-ton truck-mounted mechanical unit.
2/ Car fans were in operation an additional hour, during which time a further temperature reduction of 1.6° was obtained.
3/ Car fans were in operation an additional hour, during which time a further temperature reduction of 0.6° was obtained.

filled only once with ice (Rule 240) the day after loading. 2/ In the other four tests (tests B-E) the cars were pre-iced and precooled by means of the built-in car fans operated by electric precooling motors at the shipping point. One pair (test B) was re-iced once (Rule 251), and 3 pairs (tests C, D, and E) were given standard refrigeration; that is, re-iced three times during transit.

Mechanically refrigerated cars with thermostats set at 42° F. (Tariff Rule 700) were used in the final test (F).

Fruit in the test packages was inspected for rind breakdown and decay immediately after unloading in New York and again after holding 1 week at 70° F.

RESULTS

Precooling

Fruit temperatures in the fan cars, including the car precooled with the truck-mounted mechanical unit (test A-E), ranged from 64° to 83° F. and averaged about 75° before precooling (table 1). After 5 hours of precooling the fruit in crates had cooled an average of 7.1 degrees; that in cartons had cooled 8.7 degrees. Fruit that was precooled with a portable refrigeration unit (test A) averaged 64° before cooling and cooled about 9 degrees in each type of container during precooling. The loads cooled with ice and built-in car fans (tests B-E) averaged 76° in crates and 79.5° in cartons before cooling. The fruit in crates cooled 3 to 10 degrees and averaged 7 degrees, while that in the cartons cooled 8 to 11 degrees and averaged 8.7 degrees.

The oranges in mechanically refrigerated cars (test F) averaged about 79° before precooling. Fruit in crates cooled 4.8 degrees during precooling, while that in cartons cooled 3.7 degrees. The rate of cooling during precooling in mechanical cars was only about one-half as fast as with portable, truck-mounted equipment or car fans and ice.

Icing Service

In test A, which was conducted in April, the cars received approximately 10,000 pounds of ice per car (Rule 240) (table 2). Fruit temperature was reduced about 19 degrees. In test B, also conducted in April, cars received more than 19,000 pounds of ice per car (Rule 251), resulting in a temperature reduction of about 30 degrees. In tests C, D, and E, conducted in June, carlots received between 27,500 and 30,000 pounds of ice per car before arrival

---

2/ The railroad designations for the icing services used in these tests are as follows:

Rule 240: Initially iced before loading or at first icing station in transit; do not re-ice.

Rule 251: Initially iced before or after loading and re-iced once during transit.

Rule 201: Standard refrigeration: Initially iced before or after loading and re-iced at all regular icing stations.

Table 2.--Temperatures of fruit at loading and in transit, as affected by container, load pattern, and refrigeration service (average of three positions in the load)

Type of car and shipping container	Icing service: Pre-iced	Re-iced en route	Total ice supplied before: Arriving Jersey City area	Total ice supplied before: Unloading at New York City	Ice remaining in bunkers at time of unloading	Total ice meltage	Temperatures: End of loading 1/	First midnight	Day 1: Noon	Day 1: Midnight	Day 2: Noon	Day 2: Midnight	Day 3: Noon	Day 3: Midnight	Day 4: Noon	Day 4: Midnight	Average in transit
			Pounds	Pounds	Pounds	Pounds	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
End-bunker fan cars:																	
Test A: 2/																	
Crates	0	1	10,000	10,000	3,750	6,250	65	56	53	49	47	45	45	44	---	---	48
Cartons	0	1	9,600	9,600	4,800	4,800	64	55	54	52	50	49	48	47	---	---	51
Test B: 3/																	
Crates	1	1	19,600	27,600	8,750	18,850	73	61	57	55	51	47	44	44	42	42	49
Cartons	1	1	19,200	26,700	8,400	18,300	76	60	57	56	54	50	46	45	44	44	51
Test C: 4/																	
Crates	1	3	28,200	34,400	5,820	28,580	79	68	63	56	54	50	46	45	44	43	52
Cartons	1	3	29,800	36,600	5,820	30,780	83	71	66	60	57	53	50	48	46	44	55
Test D: 5/																	
Crates	1	3	28,800	28,800	4,686	24,114	71	70	67	62	57	57	54	52	50	50	58
Cartons	1	3	30,000	30,000	4,056	25,944	80	73	70	63	59	58	55	53	52	51	59
Test E: 6/																	
Crates	1	3	27,500	33,000	6,832	26,168	82	78	71	66	61	57	53	51	49	47	59
Cartons	1	3	27,500	32,700	8,416	24,284	79	72	66	61	56	52	50	48	47	47	55
Average--tests A-E:																	
Crates	---	---	---	---	---	---	74	66	62	58	54	52	48	47	46	45	53
Cartons	---	---	---	---	---	---	76	66	62	59	55	52	50	48	47	46	54
Average--tests B-E:																	
Crates	---	---	---	---	---	---	76	69	65	60	56	53	49	48	46	45	55
Cartons	---	---	---	---	---	---	80	69	65	60	56	53	50	48	47	46	55
Mechanically refrigerated cars:																	
Test F:																	
Crates	---	---	---	---	---	---	79	70	59	54	52	48	46	45	45	44	51
Cartons	---	---	---	---	---	---	80	70	60	53	49	47	46	46	45	45	51

1/ Average of 10 electric resistance thermometer readings. Later readings were from thermograph recordings.

2/ Initially iced about 8 a.m. first day after loading, with no subsequent icing service.

3/ Initially iced about 5 p.m. the day before loading; re-iced between 5 a.m. and 9 a.m. second day after loading and at Jersey City about 9 p.m. third day after loading.

4/ Initially iced about 5 p.m. the day before loading; re-iced about 8 a.m. the first day after loading, about 11 a.m. the second day after loading, near midnight the second day after loading and at Jersey City about noon of the fourth day after loading.

5/ Initially iced about 5 p.m. the day before loading; re-iced about 8 a.m. the day after loading, about 10 a.m. the second day after loading, and in the early morning of the third day after loading.

6/ Initially iced about 6 p.m. the day before loading; re-iced about 7 a.m. the first day after loading, about 8 a.m. the second day after loading, near midnight the second day after loading and at Jersey City in midafternoon of the fourth day after loading.

at New York City (Rule 201, Standard refrigeration), and the fruit temperatures had been reduced about 30 degrees. Because of delayed unloading, the cars in tests B, C, and E were given an additional re-icing after arrival. By that time the ice had reduced the average fruit temperature from 79° to about 45° F.

The total amount of ice supplied south of Jersey City ranged from about 9,600 pounds in April to 30,000 pounds in June and averaged slightly more than 23,000 pounds per car for the cartons and crates alike. The temperatures of loads cooled with ice only (tests B-E) ranged from 71° to 83° at loading and 42° to 51° at unloading, 4 days later. Ice meltage was not consistently related to the type of container. The total ice meltage to the hour of unloading in all cars (tests A-E) was 103,962 pounds for the shipments in crates and 104,108 pounds for the shipments in cartons, a difference of only 146 pounds.

Temperatures in Transit

Temperatures in transit are shown at 12-hour intervals from the first midnight after loading when the cars had been in transit only 2 or 3 hours, until the fourth or fifth midnight (table 2). Transit cooling in the ice refrigerated cars resulted in the average temperature of the loads in crates being reduced from 66° to 45° F. The overall average transit temperature was 53° for the 4-day period. In the cartons the average temperature was reduced from 66° to 46° in transit with an overall average transit temperature of 54°. The average transit temperatures ranged from 48° in April to 59° in June. The fruit in the April shipments cooled to 50° or below by midnight of the second day in transit; that is, by the time the cars had reached Potomac Yards, Alexandria, Va. In only three of the six end-bunker cars shipped in June was the temperature lower than 50° by midnight of the third day in transit when the cars had reached the Jersey City area.

When the top, middle, and bottom layers in end-bunker iced cars are considered separately, it is seen that transit temperature of the fruit at the doorway averaged 52° F. in crates and 54° in cartons (table 3). In the middle quarterlength position the average was 56° in crates and 58° in cartons. In the bottom bunker position the temperatures averaged 51° in crates and 50° in cartons.

The middle quarterlength position was consistently the warmest location in the loads of crates and cartons alike. The top doorway of the loads in crates was the coolest until midnight of the second day in transit. By the following midnight the bottom bunker position had become the coolest location. The bottom bunker position was the coolest part of the loads in cartons after the first midnight. The greatest temperature spread between the warmest and coolest locations was 10 degrees in crates and 11 degrees in cartons. The spread averaged 6 degrees for the crates and 7 degrees for the cartons. The greatest divergence occurred during the fourth day after loading when the cars probably were at destination awaiting unloading, and the car fans were not in operation.

Table 3.--Temperatures of oranges and grapefruit in transit in rail cars, by position in load

Type of car, container, and position in load	Loading day	Days in transit								Average
		1		2		3		4		
	Midnight	Noon	Midnight	Noon	Midnight	Noon	Midnight	Noon	Midnight	
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
End-bunker fan cars: 1/										
Crates:										
Top doorway	64	60	55	51	49	47	47	48	48	52
Middle quarterlength	69	66	61	57	54	51	50	50	49	56
Bottom bunker	66	61	57	54	52	47	45	41	39	51
Spread	5	6	6	6	5	4	5	9	10	6
Cartons:										
Top doorway	64	61	57	55	52	50	50	50	50	54
Middle quarterlength	69	66	63	59	56	54	51	51	50	58
Bottom bunker	65	60	56	52	50	46	44	41	39	50
Spread	5	6	7	7	6	8	7	10	11	7
Mechanically refrigerated cars: 2/										
Crates:										
Top doorway	70	60	56	55	50	48	46	46	45	53
Middle quarterlength	71	58	54	52	47	45	44	44	43	51
Bottom bunker	69	59	53	50	46	46	45	45	44	51
Spread	2	2	3	5	4	3	2	2	2	3
Cartons:										
Top doorway	71	61	54	50	47	47	47	47	47	52
Middle quarterlength	66	56	51	48	46	46	46	44	44	50
Bottom bunker	74	64	55	50	47	46	45	45	45	52
Spread	8	8	4	2	1	1	2	2	2	3

1/ Average of tests A-E.
2/ Test F.

In the mechanically refrigerated cars the average temperature of fruit in crates was reduced from 70° to 44° F. in transit with an average transit temperature of 51° (table 2). In cartons the average temperature was reduced from 70° to 45° with an average transit temperature of 51°. Transit temperatures at the top doorway position of the mechanical cars averaged 53° in crates and 52° in cartons, at the middle quarterlength position 51° in crates and 50° in cartons, and at the bottom bunker position 51° and 52°, respectively (table 3). The top doorway position was the warmest part of the load in crates during the transit period. During the first 24 hours after loading, the bottom bunker position in the car of cartons was the warmest; later, the top doorway position was the warmest. The spread in temperatures in crates ranged from 2 to 5 degrees and averaged 3 degrees, while in cartons the spread ranged from 1 to 8 degrees and averaged 3 degrees.

Although the rate of cooling during the first 5 hours after loading was slower in mechanically refrigerated cars than in ice-refrigerated fan cars, the fruit in the former cooled faster thereafter, and remained at a lower temperature until unloaded.

Rind Breakdown and Decay

Grapefruit

Rind breakdown, mostly pitting, was present on arrival at New York City on about 3 percent of the grapefruit, of which 1 percent was scorable; that is, severe enough to be discounted on the market (table 4). Scorable rind breakdown increased only about 2 percent during the 7-day holding period at 70° F. Total rind breakdown affected 4 to 5 percent of the fruit. There was less than 0.5 percent decay on arrival, but after 1 week there was 4 percent in the crates and 7 percent in the cartons, most of which was green mold rot. This difference in percentage of decay is too slight to be significant.

Oranges

On arrival at New York City there was 1 percent total rind breakdown, mostly pitting, in crates and 2 percent in cartons, of which one-half was scorable. One week later there was 1 percent scorable rind breakdown in crates and less than 0.5 percent in cartons, with total rind breakdown amounting to 4 percent and 2 percent, respectively. One percent of the fruit in crates and less than 0.5 percent in the cartons had decay on arrival. After 1 week it had increased to 19 percent in both containers, most of which was stem-end rot.

DISCUSSION

One of the major problems with cooling loads of perishable produce in transit is getting the full cooling capacity of the available refrigeration to work on the commodity. Both container design and load pattern affect the rate of cooling. Fruit in the package with the greatest amount of

Table 4.--Development of rind breakdown and decay in grapefruit and oranges, when unloaded and after 7 day's storage, by type of container, 1958

Kind of fruit and type of container	Fruit	At unloading, New York City						
		Rind breakdown 1/			Decay			
		Aging	Pitting	Total	Stem-end	Penicillium	Miscellaneous	Total
	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Grapefruit:								
Crate	218	*	3 (1)	3 (1)	0	0	0	0
Carton	215	0	2	2	*	0	0	*
Oranges:								
Crate	689	0	1 (*)	1 (*)	*	1	*	1
Carton	693	0	2 (1)	2 (1)	*	0	0	*

Kind of fruit and type of container	Fruit	After 7 days' storage at 70° F.						
		Rind breakdown 1/			Decay			
		Aging	Pitting	Total	Stem-end	Penicillium	Miscellaneous	Total
	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Grapefruit:								
Crate	214	2	3 (2)	5 (2)	1	3	0	4
Carton	204	1 (1)	3 (2)	4 (3)	2	3	2	7
Oranges:								
Crate	681	1	3 (1)	4 (1)	18	1	0	19
Carton	691	*	2 (*)	2 (*)	17	2	0	19

* Less than 0.5 percent.
1/ Digit in ( )--Percentage of fruit with scorable rind breakdown (aggregate damage larger than a dime)

ventilation and loaded in the pattern which permits the best circulation of air between or through the containers would be expected to cool most rapidly. In these studies fruit in wirebound crates loaded in the customarily used layer-offset pattern cooled at about the same rate as fruit in cartons loaded by the more open "spaced bonded-block" pattern customarily used for this type of container. Had the same pattern of loading been followed with both containers, there might have been a difference in the rate of cooling. However, it remains to be determined whether the more open load would result in increased breakage of wirebound crates.

In ice-refrigerated fan cars in which fruit is precooled with car fans, as in test B, and shipped under Rule 251, the re-icing should be done as soon as possible in transit, or at the first icing station.

When cars arrive at market 3 days after loading with a ton or two of ice remaining and are to be held only 1 or 2 days before unloading, re-icing is rarely needed. The rise in fruit temperature during this period is usually not great enough to accelerate decay. In such cases if the consignee decides that no re-icing is necessary, he should immediately notify the carrier accordingly under the provisions of Rule 406; otherwise the carrier will re-ice the car.

The mechanically refrigerated car, commonly used in the transport of frozen foods, appears adequate for citrus when loaded with warm fruit in either crates or cartons especially in hot weather. It seems capable of reducing the temperature from about 80° to 50° by the second day after loading. During periods of acute outbreaks of decay at origin, the rate of cooling in mechanically refrigerated cars may not be fast enough. However, it seems sufficient for all practical purposes under normal conditions encountered by Florida shipments.